Listing of Claims

The following listing of claims replaces all prior versions and listings of claims in the application.

1. (Original): A liquid crystal optical modulator that has a liquid crystal molecule layer between a first substrate having thereon a plurality of stripe electrodes arranged in a stripe pattern and a second substrate having thereon opposed electrodes and that is capable of causing a modulation in a refractive index of said liquid crystal molecule layer by applying different voltages to both ends of said stripe electrodes,

wherein said second substrate has divided opposed electrodes each corresponding to a predetermined area on said stripe electrodes and

wherein the voltages are applied to said stripe electrodes and said opposed electrodes to cause said liquid crystal optical modulator to operate as a concave lens or as a convex lens, using a curve modulation area indicating characteristics that a birefringence for the voltage applied to the liquid crystal molecule layer is downwardly convex, or a curve modulation area indicating characteristics that the birefringence is upwardly convex, as a modulation area of the refractive index of said liquid crystal molecule layer.

2. (Original): A liquid crystal optical modulator that has a liquid crystal molecule layer between a first substrate having thereon a plurality of stripe electrodes arranged in a stripe pattern and a second substrate having thereon opposed electrodes and that is capable of causing a

modulation in a refractive index of said liquid crystal molecule layer by applying different voltages to both ends of said stripe electrodes,

wherein said second substrate has divided opposed electrodes each corresponding to a predetermined area on said stripe electrodes and

wherein an operation point on a phase modulation curve of the refractive index of said liquid crystal molecule layer is shifted under a phase control of a bias signal applied to said divided opposed electrodes and, at the same time, a focal length of a lens operation of said liquid crystal optical modulator is made variable by a control signal controlling said plurality of stripe electrodes.

3. (Original): The liquid crystal optical modulator according to claim 1 or 2 wherein said stripe electrodes are composed of a plurality of transparent electrodes arranged in parallel stripes.

4. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 1-3~~ claim 1 or 2, further comprising a connection stripe electrode for connecting said plurality of stripe electrodes

wherein said connection stripe electrode has a sheet resistance equal to or higher than that of said stripe electrodes.

5. (Original): The liquid crystal optical modulator according to claim 4 wherein said connection stripe electrode is composed of a transparent conductive electrode.

6. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 1-5~~ claim 1 or 2 wherein the opposed electrodes provided on said second substrate are optically transparent.

7. (Original): An optical modulator using liquid crystal comprising:

a first substrate having thereon a composite electrode in which a plurality of semicircular conductive electrodes are concentrically arranged and said plurality of concentrically-arranged conductive electrodes are electrically connected by one or more connection stripe electrodes;

a second substrate having thereon divided opposed electrodes each corresponding to a predetermined area on said composite electrode; and

an optical element including a liquid crystal molecule layer held between said first substrate and said second substrate,

wherein said connection stripe electrode has signal electrodes at ends thereof to which a control signal is applied and, by applying a predetermined voltage to the signal electrodes, a linear potential gradient is generated in the connection stripe electrode between the signal electrodes,

wherein a predetermined opposed voltage is applied to said divided opposed electrodes,

wherein, in a curve modulation area of electro-optical characteristics of homogeneously aligned or homeotropically aligned liquid crystal, the voltages are applied to cause a modulation in a refractive index of the liquid crystal molecule layer and

wherein the voltages are applied to said stripe electrodes and said opposed electrodes to cause said liquid crystal optical modulator to operate as a concave lens or as a convex lens, using a curve modulation area indicating characteristics that a birefringence for the voltage applied to the liquid crystal molecule layer is downwardly convex, or a curve modulation area indicating

characteristics that the birefringence is upwardly convex, as a modulation area of the refractive index of said liquid crystal molecule layer.

8. (Original): An optical modulator using liquid crystal comprising:

a first substrate having thereon a composite electrode in which a plurality of semicircular conductive electrodes are concentrically arranged and said plurality of concentrically-arranged conductive electrodes are electrically connected by one or more connection conductive electrodes;

a second substrate having thereon divided opposed electrodes each corresponding to a predetermined area on said composite electrode; and

an optical element including a liquid crystal molecule layer held between said first substrate and said second substrate,

wherein said connection stripe electrode has signal electrodes at ends thereof to which a control signal is applied and, by applying a predetermined voltage to the signal electrodes, a linear potential gradient is generated in the connection stripe electrode between the signal electrodes,

wherein a predetermined opposed voltage is applied to said divided opposed electrodes,

wherein, in a curve modulation area of electro-optical characteristics of homogeneously aligned or homeotropically aligned liquid crystal, the voltages are applied to cause a modulation in a refractive index of the liquid crystal molecule layer and

wherein an operation point on a phase modulation curve of the refractive index of said liquid crystal molecule layer is shifted under a phase control of a bias signal applied to said divided opposed electrodes and, at the same time, a focal length of a lens operation of said liquid crystal optical modulator is made variable by a control signal controlling said plurality of stripe electrodes.

9. (Original): The liquid crystal optical modulator according to claim 7 or 8 wherein said plurality of semicircular conductive electrodes are composed of transparent conductive electrodes.

10. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-9~~ claim 7 or 8,

wherein said connection stripe electrode has a sheet resistance equal to or higher than that of said conductive electrodes.

11. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-10~~ claim 7 or 8 wherein said connection stripe electrode is composed of a transparent conductive electrode.

12. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-11~~ claim 7 or 8 wherein the opposed electrodes provided on said second substrate are optically transparent.

13. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-12~~ claim 7 or 8 wherein two connection conductive electrodes are formed along diagonal lines of a square aperture.

14. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-13~~ claim 7 or 8 wherein said plurality of concentrically-arranged semicircular conductive electrodes have a slit part therein and are divided by said slit part into at least two groups.

15. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-14~~ claim 7 or 8 wherein a conductive electrode group composed of said plurality of concentrically-arranged semicircular conductive electrodes further includes a plurality of segment stripe conductive electrodes.

16. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 1-6~~ claim 1 or 2 wherein, for homogeneous alignment, a pre-tilt angle of the liquid crystal molecule layer is a predetermined value from 0.5 degrees to 20 degrees.

17. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-15~~ claim 7 or 8 wherein, for homogeneous alignment, a pre-tilt angle of the liquid crystal molecule layer is a predetermined value from 0.5 degrees to 20 degrees.

18. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-15~~ claim 7 or 8 wherein a director direction of the liquid crystal molecule layer is established in a direction at right angles to the slit part.

19. (Currently amended): The liquid crystal optical modulator according to ~~one of claims 7-18~~ claim 7 or 8 wherein a plurality of liquid crystal optical modulators are arranged adjacently in a two-dimensional form.

20. (Original): A method for driving an optical modulator using liquid crystal, said liquid crystal optical modulator comprising:

a first substrate having thereon a composite electrode in which a plurality of parallel stripe conductive electrodes are arranged and plurality of parallel stripe conductive electrodes are electrically connected by one or more connection stripe electrodes;

a second substrate having thereon divided opposed electrodes each corresponding to a predetermined area on said composite electrode; and

an optical element including a liquid crystal molecule layer held between said first substrate and said second substrate,

said liquid crystal optical modulator configured in such a way

that said connection stripe electrode has signal electrodes at a predetermined interval to which a control signal is applied;

that, by applying a predetermined voltage to the signal electrodes, a linear potential gradient is generated in the connection stripe electrode between the signal electrodes;

that a predetermined opposed voltage is applied to said divided opposed electrodes; and

that the applied voltages cause a modulation in a refractive index of the liquid crystal molecule layer via a curve modulation area of electro-optical characteristics of homogeneously aligned or homeotropically aligned liquid crystal,

wherein two drive waveforms, with equal amplitude and equal frequency but 180 degrees out of phase to one another, are applied to the predetermined signal electrodes that receive drive waveforms.

21. (Original): A method for driving an optical modulator using liquid crystal, said liquid crystal optical modulator comprising:

a first substrate having thereon a composite electrode in which a plurality of semicircular conductive electrodes are concentrically arranged and said plurality of concentrically-arranged conductive electrodes are electrically connected by one or more connection conductive electrodes;

a second substrate having thereon divided opposed electrodes each corresponding to a predetermined area on said composite electrode; and

an optical element including a liquid crystal molecule layer held between said first substrate and said second substrate,

said liquid crystal optical modulator configured in such a way

that said connection stripe electrode has signal electrodes at ends thereof to which a control signal is applied;

that, by applying a predetermined voltage to the signal electrodes, a linear potential gradient is generated in the connection stripe electrode between the signal electrodes;

that a predetermined opposed voltage is applied to said divided opposed electrodes; and

that the applied voltages cause a modulation in a refractive index of the liquid crystal molecule layer via a curve modulation area of electro-optical characteristics of homogeneously aligned or homeotropically aligned liquid crystal,

wherein two drive waveforms, with equal amplitude and equal frequency but 180 degrees out of phase to one another, are applied to the predetermined signal electrodes that receive drive waveforms.

22. (Original): A method for driving an optical modulator using liquid crystal, said liquid crystal optical modulator comprising:

a first substrate having thereon a composite electrode in which a plurality of parallel stripe conductive electrodes are arranged and said plurality of parallel stripe conductive electrodes are electrically connected by one or more connection stripe electrodes;

a second substrate having thereon divided opposed electrodes each corresponding to a predetermined area on said composite electrode; and

an optical element including a liquid crystal molecule layer held between said first substrate and said second substrate,

said liquid crystal optical modulator configured in such a way

that said connection stripe electrode has signal electrodes at a predetermined interval to which a control signal is applied;

that, by applying a predetermined voltage to the signal electrodes, a linear potential gradient is generated in the connection stripe electrode between the signal electrodes;

that a predetermined opposed voltage is applied to said divided opposed electrodes; and

that the applied voltages cause a modulation in a refractive index of the liquid crystal molecule layer via a curve modulation area of electro-optical characteristics of homogeneously aligned or homeotropically aligned liquid crystal,

wherein there are a period in which two drive waveforms, with equal amplitude and equal frequency but 180 degrees out of phase to one another, are applied to the predetermined signal electrodes that receive drive waveforms and a period in which an ac (alternate current) bias is applied to the liquid crystal molecule layer.

23. (Original): A method for driving an optical modulator using liquid crystal, said liquid crystal optical modulator comprising:

a first substrate having thereon a composite electrode in which a plurality of semicircular conductive electrodes are concentrically arranged and said plurality of concentrically-arranged conductive electrodes are electrically connected by one or more connection conductive electrodes;

a second substrate having thereon divided opposed electrodes each corresponding to a predetermined area on said composite electrode; and

an optical element including a liquid crystal molecule layer held between said first substrate and said second substrate,

said liquid crystal optical modulator configured in such a way

that said connection stripe electrode has signal electrodes at ends thereof to which a control signal is applied;

that, by applying a predetermined voltage to the signal electrodes, a linear potential gradient is generated in the connection stripe electrode between the signal electrodes;

that a predetermined opposed voltage is applied to said divided opposed electrodes; and

that the applied voltages cause a modulation in a refractive index of the liquid crystal molecule layer via a curve modulation area of electro-optical characteristics of homogeneously aligned or homeotropically aligned liquid crystal,

wherein there are a period in which two drive waveforms, with equal amplitude and equal frequency but 180 degrees out of phase to one another, are applied to the predetermined signal electrodes that receive drive waveforms and a period in which an ac bias is applied to the liquid crystal molecule layer.